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## ML partners with brass quintet for instrument testing

by **Timothy R. Anderl, Materials and Manufacturing Directorate**

WRIGHT-PATTERSON AIR FORCE BASE, Ohio — The Air Force Research Laboratory's Materials and Manufacturing Directorate (ML) is collaborating with the world renowned Canadian Brass quintet to better understand how advanced materials, which the directorate develops for air and space components, can be applied to musical instruments.

This activity resulted from the Brass' interest in these materials and the benefits they may provide to their instruments. The Brass' tuba player currently uses a carbon-fiber-reinforced polymer matrix composite (PMC) tuba bell, and the benefits he has experienced may also be applied to additional instruments such as trumpets, trombones and French horns. The directorate expects that activities initiated by ML, while addressing musical components, will also lead to a better understanding of how these materials will perform in Air Force applications.

According to Dr. Allan Katz, chief of the directorate's Ceramics Branch, dialog between the Brass and the directorate was initiated by his wife, a member of the Dayton Philharmonic Orchestra (DPO). She observed the unusual PMC tuba bell when the Brass performed during a DPO concert and arranged a quick meeting between the Brass and Dr. Katz. It was clear from this initial, brief discussion that the members of the Brass were interested in learning about composites and other advanced materials that might be applied to their instruments.

A small group discussion between composites engineers from the directorate and the Brass was arranged in July 2002 in conjunction with the group's performance with the Dayton Philharmonic Orchestra at the Frazee Pavilion, Kettering. Dialog with the Brass continued with a visit to the directorate in December, when the Brass was performing in Cincinnati and Springfield. During the visit, members of the Brass displayed and demonstrated their instruments. This allowed ML scientists to hear and appreciate the differences in sound between various instrument configurations, Katz said.

Researchers were particularly interested in the demonstration of four PMC tuba bells, as well as a PMC trumpet mute. According to Katz, the best of the PMC bells provided a richness and clarity of sound that was very noticeable when compared to the other bells. The PMC bells had been custom made at the Brass' request, most of them by the Yamaha Band and Orchestra Division with whom the Brass has a close working relationship. The bells were of different thicknesses and composite constructions, which the researchers believe relate to the resulting differences in sound character.



*Canadian Brass member Ryan Anthony demonstrates a carbon-fiber-reinforced polymer matrix composite (PMC) trumpet mute during a meeting with scientists and engineers from the Materials and Manufacturing Directorate.*

The tuba player reported that the PMC bells (versus brass) produce sound that can be heard well at the ear while also projecting into the performance hall, and are more responsive.

The PMC trumpet mute was also of special interest to directorate scientists, Katz said. Unlike metallic mutes, the composite mute did not alter pitch or playing resistance with the degree of muting applied by the musician.

"The visit in December reinforced the notion that we can contribute to increased understanding of the role of advanced materials in traditional 'brass' instruments," Katz said. "The issues, in many ways, are similar to ones we face in aerospace applications."

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“For example, though hot exhaust washed ducts and engine cowlings found on aircraft are not an exact match, the tuba bell does bear some resemblance,” said Tia BensonTolle, chief of the directorate’s Structural Materials Branch. “Aircraft components are often acoustically excited, and vibrational modes, resonances and damping can be critical to performance of systems in an operational environment where excess vibration can cause material fatigue and unwanted noise levels in an aircraft. Understanding these parameters and how to control and apply them to materials selection and design, whether for aerospace components or musical instruments, bears a keen resemblance and importance to materials such as composites.”

The collaboration between the directorate and the Canadian Brass will allow them to discover how advanced materials characteristics impact sound character. The directorate will use this understanding to help select and design materials that will sound better and will be more responsive for the musician while gaining important knowledge about vibration and damping properties of materials in Air Force structures.

Among first activities that the partners planned, the directorate enlisted the support of Navy colleagues who have developed a novel technique for measuring resonant frequencies and damping in composite structures. Preliminary data obtained from two PMC tuba bells show differences that may lead to key insights, said BensonTolle. ML personnel met with Navy researchers recently to learn the results firsthand and to observe their research technique. Scientists at the directorate expect to apply the method to analysis of a range of materials and structures of interest to the Air Force.

As time and resources permit, ML personnel also plan to fabricate small components in the lab, with varied materials design (for example, with different fiber reinforcement architecture), to assess the impact on musical sound character. These components may include PMC mouthpieces, lead pipes (the small transition piece between the mouthpiece and the body of the instrument), and mutes.

According to Dr. Mark Tudela, a directorate researcher who specializes in characterizing material behavior, they will initially focus on the French horn bell because it is small enough to be fabricated in-house, with varying PMC constructions. The French horn is configured to accept interchangeable bells, which will permit the direct comparison of audible sound character and the measurement of vibration characteristics in differing PMC bells. Tudela suggested that the directorate might also examine metal alternatives to brass for mouthpieces, and ceramics for valves.

“The materials design and fabrication will be a valuable learning experience since musical characteristics are an interesting and challenging measure of materials performance,” Tudela said. “Any applicability to traditional brass instruments or to fighter aircraft would be an added benefit.”

“Ultimately, the goal of the Canadian Brass is to improve their instruments by use of advanced materials, to find suppliers who will employ these materials to make the musical components, and to educate the public so that the use of these materials for instruments becomes more widespread,” Katz added. “These aims are fully consistent with the Air Force’s technology transfer interests. We also expect to learn much during this collaboration about the behavior of a number of Air Force structural components and materials that will help us achieve the valuable properties and characteristics that we desire.” @